CAL Software Review

Recon, Sim Considerations Status, Plans

SLAC, September 2000

Collège de France

CAL Recon : High Level Goals

- Get the Best Energy Resolution

  Best means SRD or better

- Maximise Effective Area

  Efficiency of Cuts vs. Tails in Reconstructed Energy distributions

- Give Discriminate Observables for Background Rejection

  LAT needs a factor ~100 rejection from CAL (x ~ 1000 ACD)n

  Moments, Shower Topological variables, Clusters, ...

- Feedback with TKR to improve PSF (and Energy Resolution)

  Clusters, Moments, ...

- VHE CalOnly events :

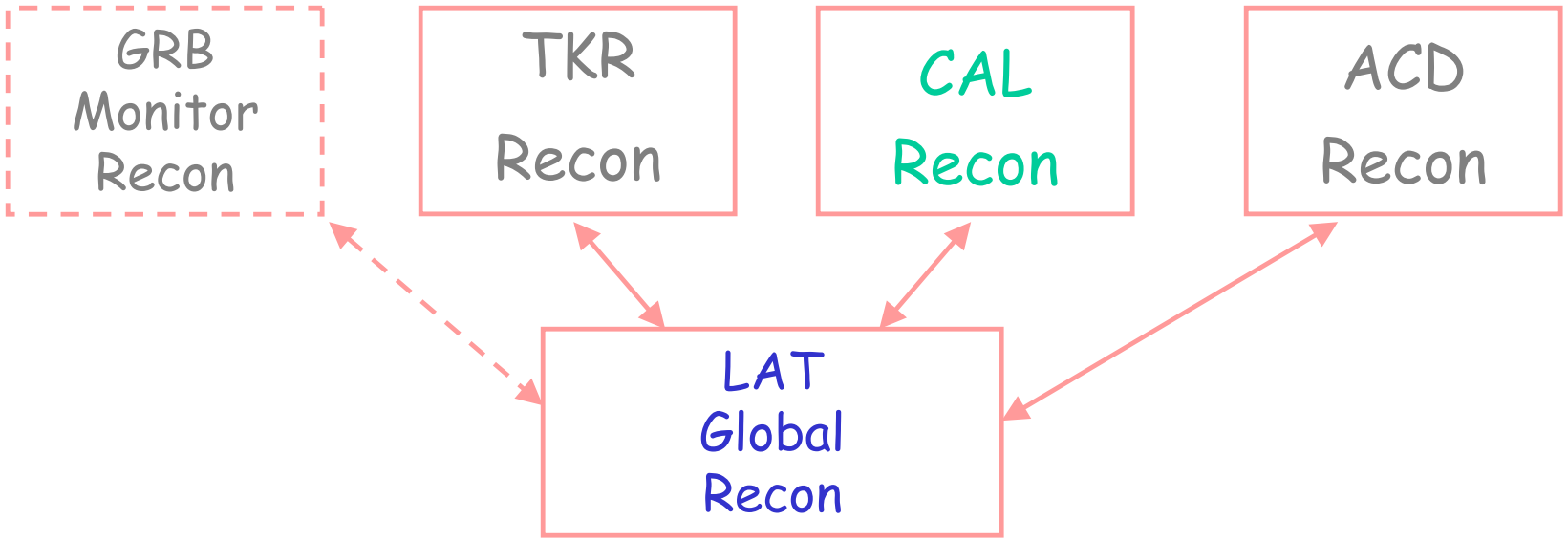
  Energy and Direction determination

Recon : General Overview

- Philosophy :

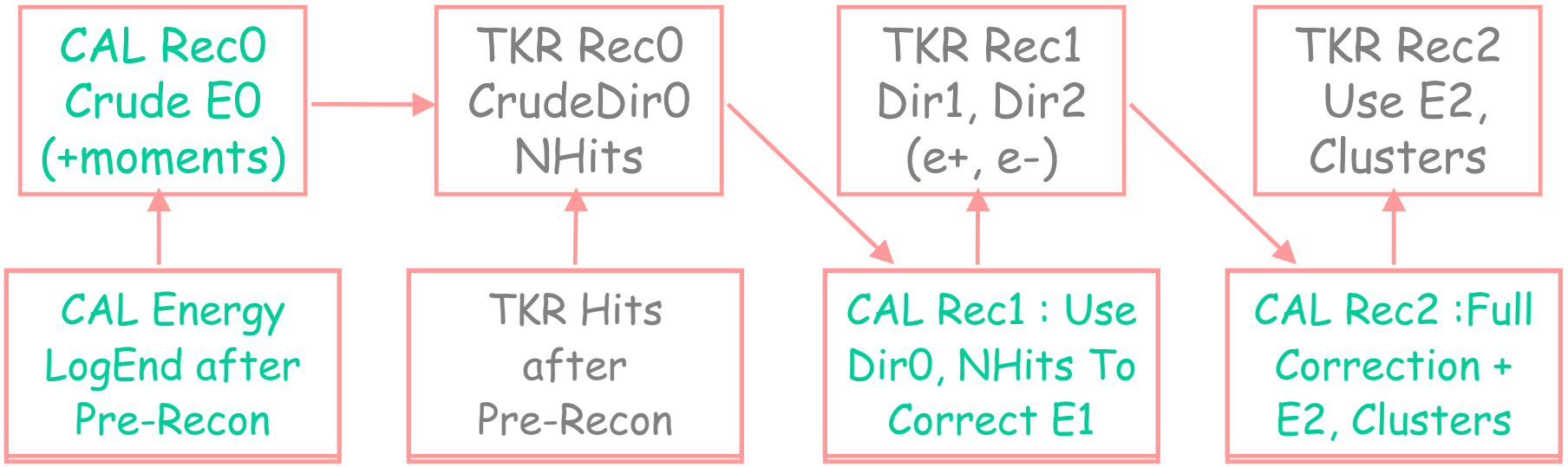
  Global Event Recon (After sub-system Recon)

  Means Requirements at the LAT level



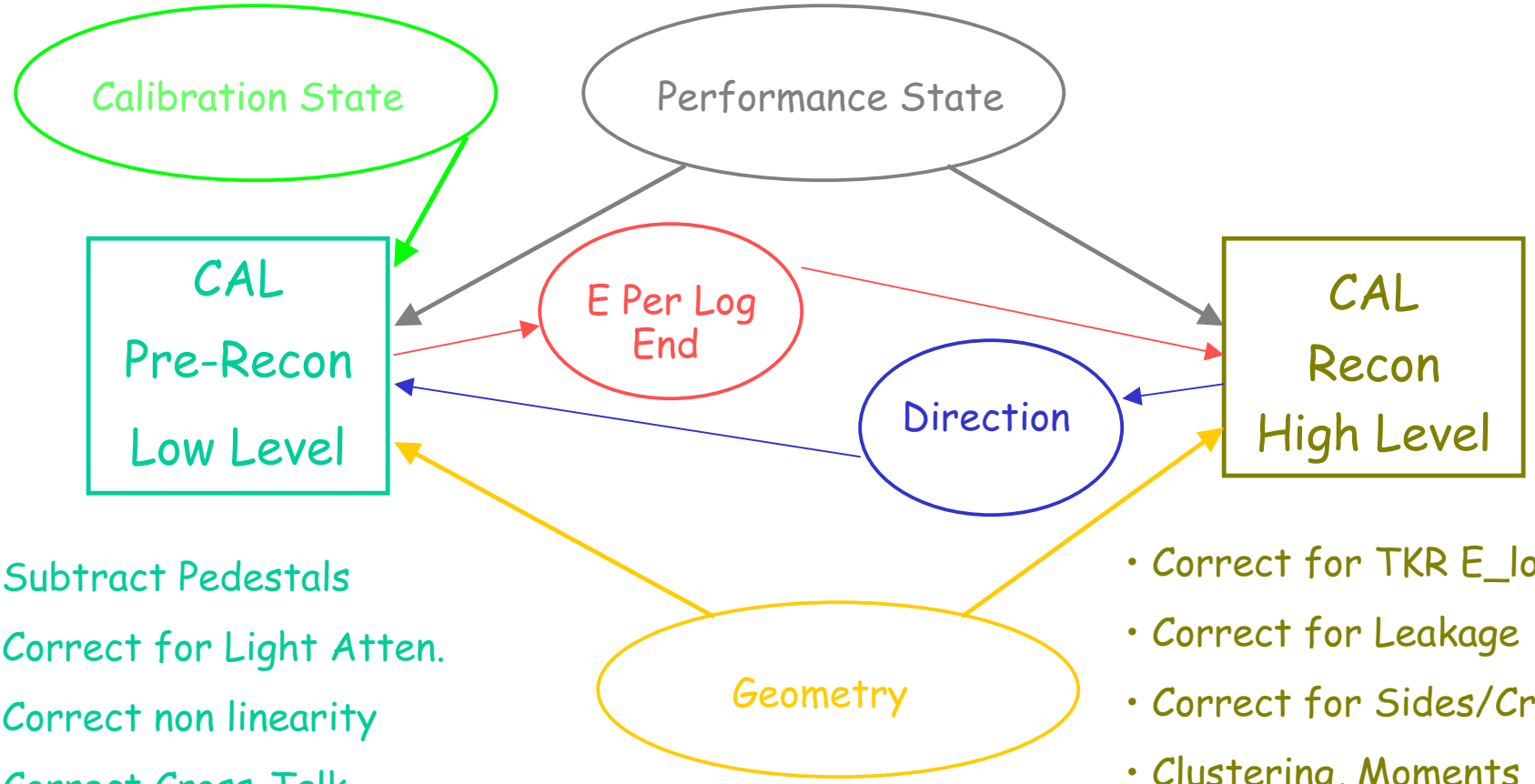
Recon : General Overview

- Illustration : feedback btw CAL and TKR :



E.g., In Gaudi, CAL and TKR Communicate through Transient Data Store

2 Steps : Pre-Recon & Recon



- Subtract Pedestals
- Correct for Light Atten.
- Correct non linearity
- Correct Cross-Talk
- Apply Gains

- Correct for TKR E_loss
- Correct for Leakage
- Correct for Sides/Cracks
- Clustering, Moments
- Yield BackGr. Rej. Vars

Pre-Recon : Low Level Corrections

- Pre-recon is the Starting point before Recon :
  - Subtract Pedestals
  - Light Attenuation Correction
  - Non-Linearity Corrections
  - Gain Corrections
  - Cross-talk Corrections
  - Saturation Effects

Input : from Calibration, Performance State, Geometry, CALRec0

Direction/ Impact needed to correct for light attenuation

Output : Energy per Log

Recon : High Level Corrections

Geometry is everywhere

- Recon is the High level Correction after Pre-Recon :

Perf. State is everywhere

Correct for Energy lost in TKR

Correct for " Back" Leakage

Correct for Sides/Cracks

Yield Background Rejection Observables

Yield Feedback Observables to other sub-systems

Clustering, Moments, ...

CALRec0:

Input : from Pre-Recon CAL Private

E_Log_End, Pedestal, Light Atten. Gain & Linearity Corrected.

Output : E0, moments0, ... To TKRRec0, ...

Recon : High Level Corrections

Geometry is everywhere

- CALRec1:

  Input : Dir0, NHits from TKRRec0

  Xtal Longitudinal Attenuation Correction

  1st pass E_Loss in TKR, E_Leakage "Back", "Sides/ Cracks"

  Output : E2, moments1, … To TKRRec1, …

Perf. State is everywhere

- CALRec2:

  Input : Tracks[i], Vertex[i], Xi2[i], from TKRRec1

  Full Correction = f(Θ, Φ, Xcal, Ycal, Vertex, …)

  Output : E2, ΔE, Clusters, Dir (if CalOnly), Backgr. Rejection Vars, …

  To TKRRec2, To Science Analysis (….)

Sim + Recon : S/W Task Levels

Different Levels of Tasks :

1- Prototypes to develop & test physics/ instrument optimisation ideas

- Algorithm development
- Includes Beam Tests to anchor ideas into real world
- Need for a collaboration wide s/w tool for feedback between sub-systems
- Glastsim has fulfilled this role till now for SIM & Recon
- TBRecon should do it for TB, Balloon etc…

2 - Write Requirements (RQMTs) according to Step 1 & SRD !

3 - Data Objects Definitions according to RQMTs

- Module Inputs, Outputs
- Transient Objects + Converters

Sim + Recon : S/W Task Levels

4 - Computational Code/Algorithm

- Performance : precision, time consummation, ...

5 - Services :

- Histogramming
- Intermediate Tuples

6 - Test and validation Modules

7 - Implementation

- Interaction with other modules
- Global Performance

Recon : Where We Are & Where to Go

- High Energy Corrections :
  - 2 methods :

    Profile fitting (Pfit) and Correlations with last Layer (Ce7);
    Pfit Implemented only in LATRecon ; Both Impl. in TBRecon

⇒ Level 1 : Complete current Algos, Merge TBRecon & LATRecon?

Short term (Regis, Sacha, merging: UW ?)

⇒ Develop new Algos

Level 2 : RQMTs : Short term (Eric, Arache)

Level 1 & 4 : Mid Term (Regis PHD+?)

Recon : Where We Are & Where to Go

- Low energy Corrections :

  Prototype for LATRecon & GTOCC; Not yet implemented ;

  MC Extraction of Coefficients not yet fully automated ;

  ⇒ Level 1 : Implement for TBRecon

  Run TBSim ; Extract Coefficients ;

  Implement (Arache + Sacha +?) Short Term;
  LATRecon : Await Migration to Gaudi ?; Mid Term?

  ⇒ Level 2 : RQMNTs

- Side/ Cracks Corrections

  Ideas ; Few Tries - No implementation ;

  ⇒ Level 1 : Build Prototypes (who?); Mid Term

  Level 2 : RQMNTs (Eric +Arache) Short Term;

Recon : Where We Are & Where to Go

- Discriminant Variables for Background Rejection

  AO status unchanged ;

  ⇒ Level 1 : Improve moments (smarter weights) Mid Term (CdF?)

  Level 1 : Clusters : Build Prototypes (who?) Short term

  ⇒ Level 2 : RQMNTs (Eric +Arache) Short term

- Feedback with TKR :

  Some Class Definitions exist (CdF, UCSC);

  ⇒ Level 1 : Prototypes Short Term (who?) Short term

  ⇒ Level 2 : RQMNTs (CAL + TKR)

- Failure modes handling ; adaptation

  NULL;

  ⇒ Level 2 : RQMNTs (CAL + TKR)

Recon : Related s/w Tasks

- Pre-Recon (Pedestals, Light Atten, Gains, Linearity corrections)
- Calibration s/w
- Validation on Beam Tests
- Production
- Reprocessing

} @ LAT Level

Improvements, Decisions @ CAL Level

- Yield the Energy Resolution Function for Science Analysis

- ...

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Energy Resolution Function

- The Energy Resolution Function (ERF!) is as important as Recon to do Science Analysis !
- It is derived through extensive simulations of the instrument @ the LAT level, … and Test Beam runs.
- It is a function of (E_true, E_estimate, Θ, Φ, Xcal, Ycal, Vertex, …)
- It is dependant on Performance State
- Questions :
  - How do we apply Recon Performance change into ERF?

    Reprocessing of Data for better Recon means also new ERF, Aeff
  - How often will we have to generate it?
  - Is it possible to anticipate failure modes effects by MC

    e.g., resolution drops as f=(number of dead logs) …

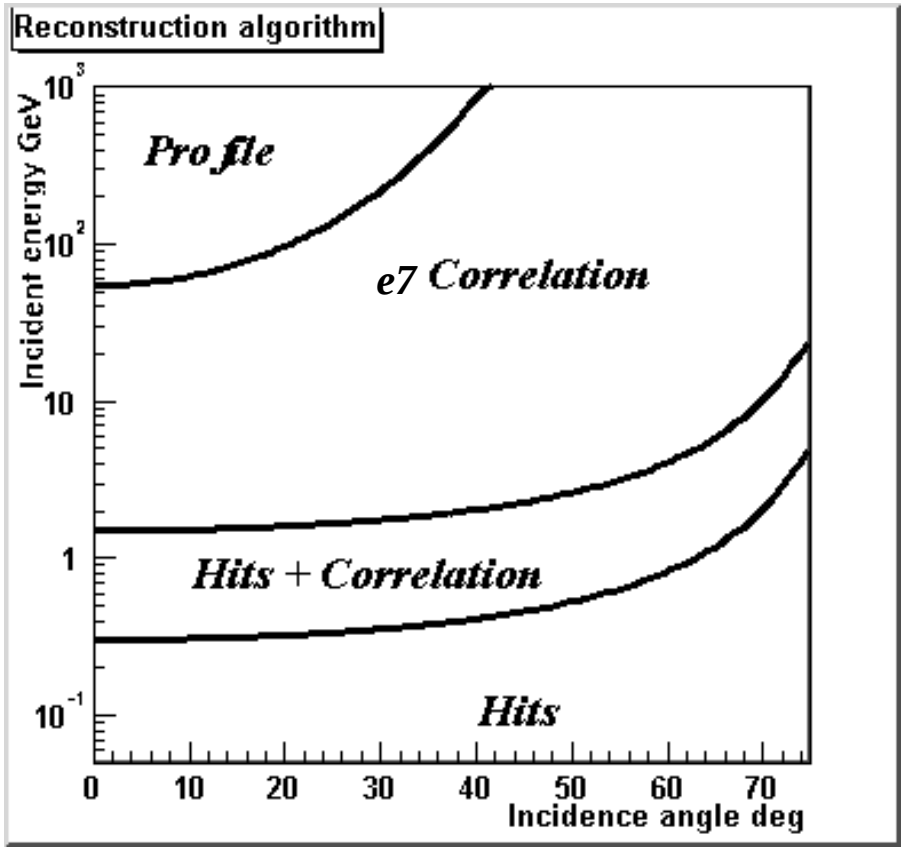
    Problem to be addressed @ LAT Level

Recon : Correction Algorithms Overview

- Correction Algo = function of Energy, Angle : Current Status

When the Shower Maximum is not contained (~60 GeV @ 0°), The Correlation method using e7 doesn't work anymore

@ E < few 100 MeV Eenergy Loss in the tracker is dominant



Recon : Low Energy Corrections

- Starting point :

  A non negligible fraction of Energy is lost

  in the TKR Below a few 100 MeV

- Use Correlation btw E_Lost and TKR Nhits :
- Definitions :

$$E_0 = E^{cal}_{seen} + E_{leak}$$

$$E_{leak} = \alpha * N_{hits} + \beta$$

- Generate MC runs @ various E, θ

Recon : Low Energy Corrections

- Fit coefficients as a function of MC Truth

  Energy, θ, Vertex

$$\begin{cases} \alpha = \alpha(E_0, \theta, vertex) \\ \beta = \beta(E_0, \theta, vertex) \end{cases}$$

1st Source of error : model to fit, errors of fit, ...

- For real events E_True is unknown : so one has to use :

2st Source of error : dispersion of α & β

wrong E, wrong θ

$$\begin{cases} \alpha = \alpha\left(E^{cal}_{seen}, \theta, vertex\right) \\ \beta = \beta\left(E^{cal}_{seen}, \theta, vertex\right) \end{cases}$$

- Then use an iterative method :

$$\begin{cases} E_1 = E^{cal}_{seen} + \alpha\left(E^{cal}_{seen}, \theta, vertex\right) * N_{hits} + \beta\left(E^{cal}_{seen}, \theta, vertex\right) \\ \quad \ldots \\ E_n = E^{cal}_{seen} + \alpha\left(E_{n-1}, \theta, vertex\right) * N_{hits} + \beta\left(E_{n-1}, \theta, vertex\right) \end{cases}$$

Recon : Low Energy Corrections

- Caution !
- If one uses MC Truth $E = E^{cal}_{seen} + \alpha(E_0, \theta, vertex) * N_{hits} + \beta(E_0, \theta, vertex)$

One gets very optimistic results !!!

And this is what has been done for the AO performance @ 100 MeV, 0°

(The best way to see that is to look into the code : is there any iteration?!)

Now why does the correct method work ?

$$\sigma_E^2 = \frac{\sigma^2_{E^{cal}_{seen}} + \alpha^2 * \sigma^2_{Nhits} + 2 * \alpha * \rho_{E^{cal}_{seen}, Nhits} * \sigma_{E^{cal}_{seen}} * \sigma_{Nhits}}{(1 - (\alpha' * Nhits + \beta'))^2}$$

It works if $\alpha * \rho_{E^{cal}_{seen}, Nhits}$ gives a negative contribution to σ_E^2

Recon : Low Energy Corrections

Performance illustration

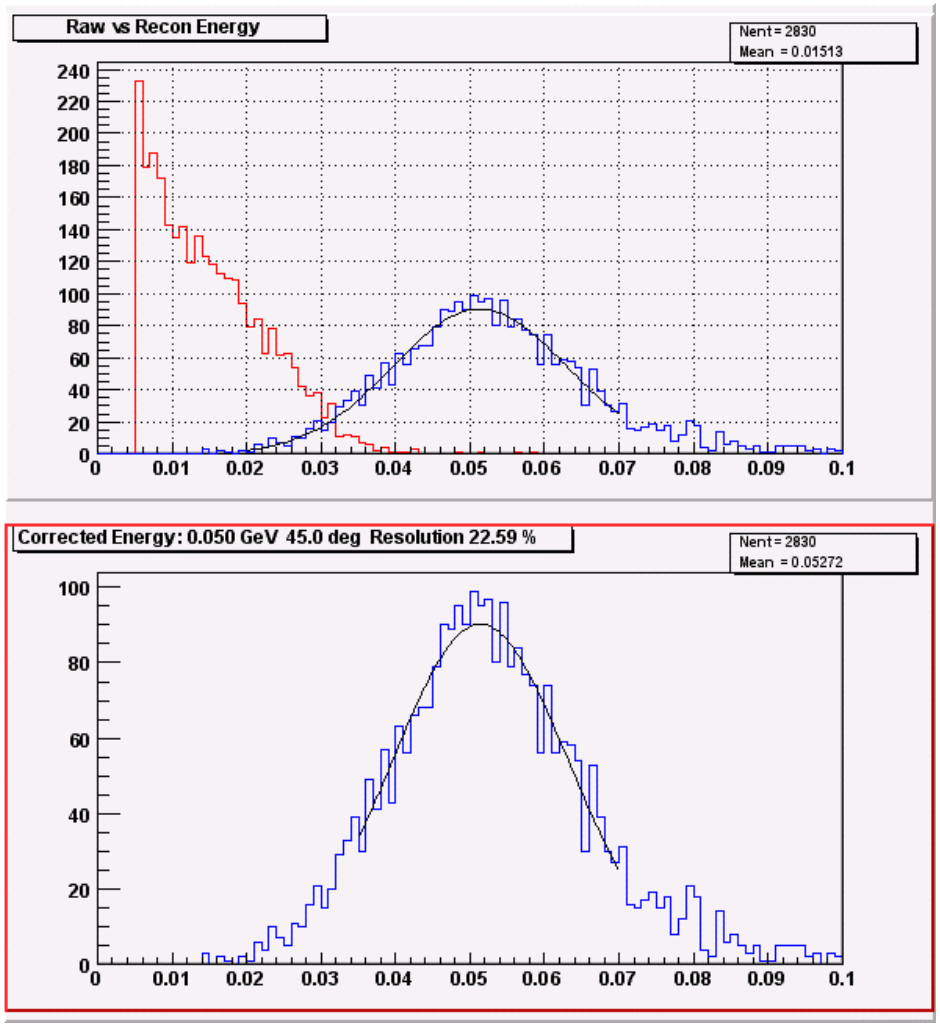
50 MeV Run @ 45° zenith

Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 23 %



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Recon : Low Energy Corrections

Performance illustration

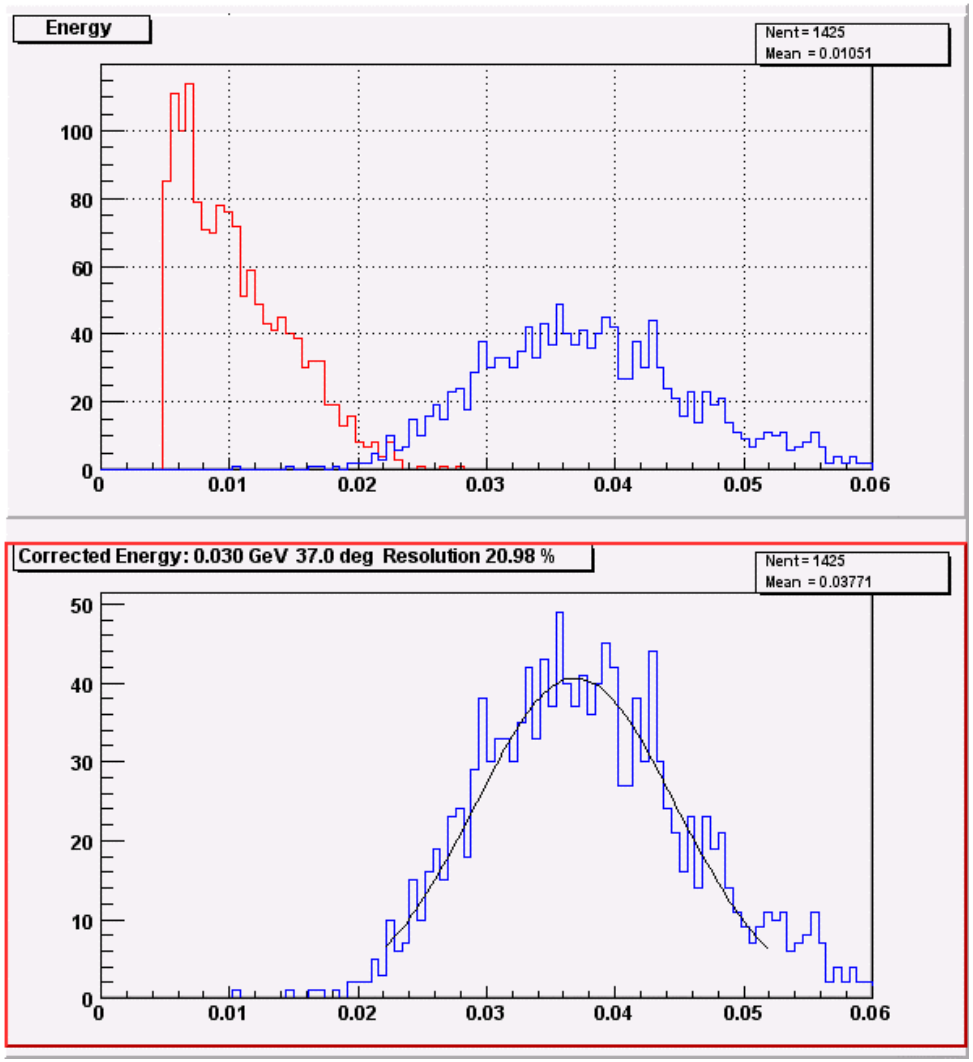
30 MeV Run @ 37° zenith

Full AO SIM

Raw Energy in Red

Recon Energy in Blue

Resolution : ~ 25 %



Recon : High Energy Corrections

- Regis's transparencies here

Recon : s/w Needs

- Minimisation Package (Midnight implemented but …)
- Interactive Graphical Display : Hits, ReconObjects

  Clustering, Rejection variables studies
- Interactive Analysis Tools

  Study of Discriminate Vars
- Event Filters
- Support for Linux/Unix Platforms (installation, etc…)
- More to come …

SIM : Where We Are & Where to Go

- CAL Geometry/ Material / Interactions

Compression Cell Concept

⇒ Level 3 : Implement Carbon Fibre Structure

Await Final Design & New Geom Framework; Mid Term (Fr)

Energy Trace in passive Material (incl TKR) , Leakage Dump

⇒ Level 1 + : Implement

Rather Short term (UW?)

dE/dx discrepancy seen in TB results

⇒ Level 1 + : Verify / Correct (muons, protons)

Very Short term (Italy?, SLAC?, UW?)

Heavy ions interactions :

⇒ Level 1 + : RQMNTs + Implement interaction model

Rather Long term wait for G4?

SIM : Where We Are & Where to Go

- Digis

  Current Status : Embedded with Hits ; see 6th july s/w telecon

  ⇒ Level 1 + : Implement CAL Hits

  Very Short term (UW? + CAL)

- Xtal Light attenuation model

  Poor Light Atten Model ;

  ⇒ Level 1 + : Implement Better model and add individual coeffs/Xtal

  Model (Eric, Gilles) Coding Sacha ; Short term for BT if needed

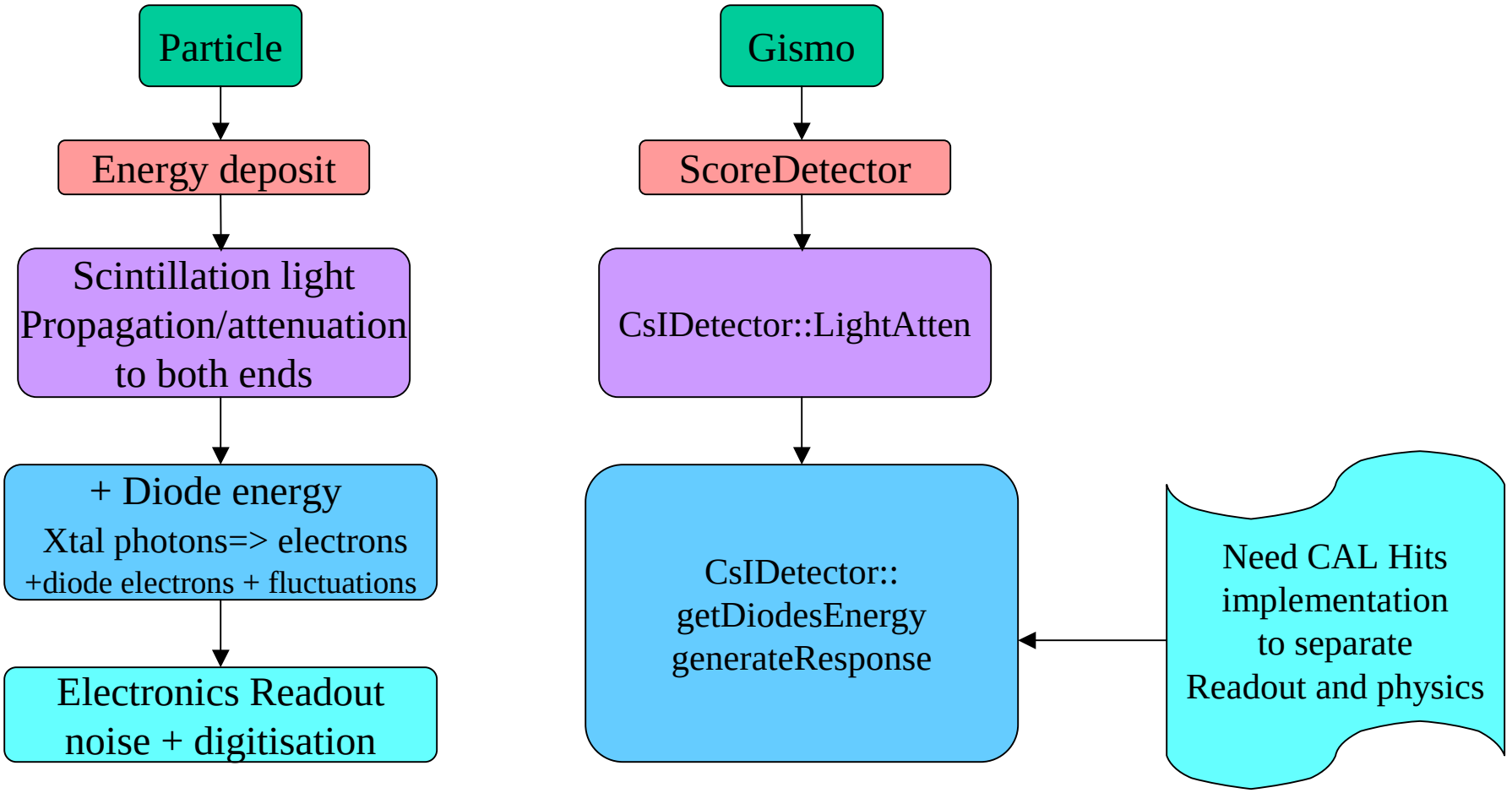
- Diodes Active + geometry : done

- FEE Electronics Noise done ;

  ⇒ Level 1 + : Generate individually for each Channel

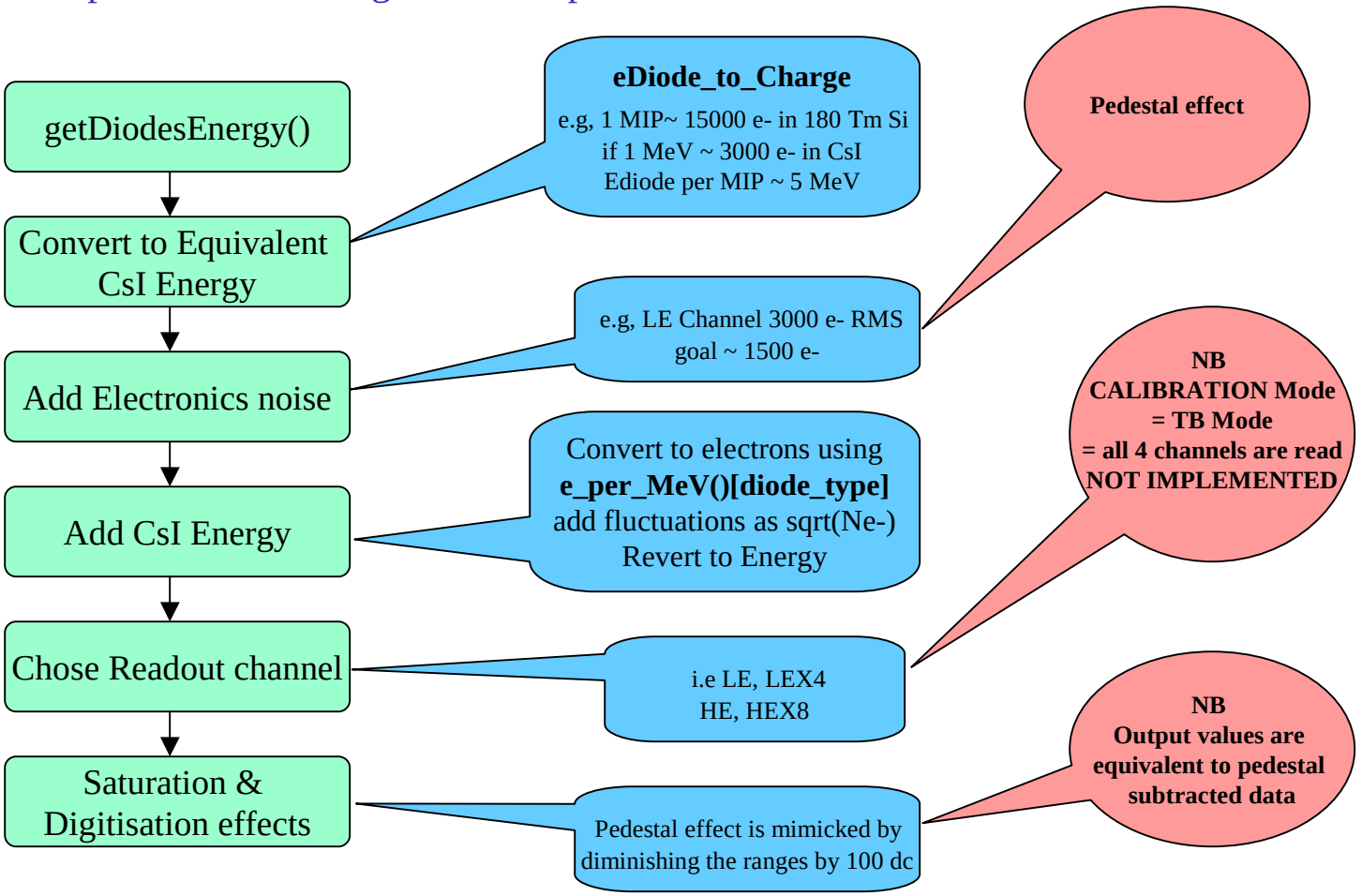
  For TB Analysis (Sacha) ; very short term

SIM : Current Embedded Hits and Digis



SIM : generateResponse ()

- What is implemented inside generateResponse ?



SIM Physics : Where We Are & Where to Go

- Digis (continued)

  Gain Ranges done ;

  ⇒ Level 1 + : Generate individually for each Channel

  For TB Analysis (Sacha); very short term

  best range Readout done

  ⇒ Level 1 + : Implement Calibration mode (4 range readout)

  Non Linearity effects

  ⇒ Level 1 + : Understand & Implement

  Cross-Talk

  Level 1 + : Understand & Implement

SIM : Needs From s/w Central

- CAL Hits & Digis separation

  Urgent !

  +Energy Trace in passive Material CAL, TKR, Leakage Dump

- Support for Migration to Gaudi

- Support for Migration to G4

- Support for Linux/Unix Platforms

- Heavy ion interactions

- More to come ...

Migrations

- Two Major Migrations are planned for GLAST S/W

- Interference with current code development has to be prepared, anticipated as much as possible

- GAUDI

  Rewrite Algorithms/Constants after requirements

- GEANT 4

  Geometry Framework ; Interactive Display, ...

New Code Policy

- **One** person should be responsible for one module, in terms of :
  - Final agreement btw RQMNTs & Code
  - That includes :
    - performance,
    - documentation,
    - test modules,
    - Interaction with other modules, sub-systems
- Other developers should communicate with and through him (but not only …)
- The Preliminary steps are :
    - Requirements
    - task sharing, volunteering , assignment?!

Test Beam Status : TBRecon

- Pre-Recon, Calibration (see Eric for details):

  Gains files status :

  - old gains : one fixed gain per range (0-1-2-3) for all log ends

    No rails, no Linearity Corrections, no Slope Corrections

  - new gains :

    Individual gains per range (0-1)

    Rails, Linearity Corrections, Slope Corrections

    Fixed gains for ranges (2-3) for all log ends

    Rails, Linearity Corrections, Slope Corrections

    For all Ranges, the rails are multiplied by 0.6 to avoid the high non linear zone btw 3000 & 4000 adc counts

Test Beam Status : TBRecon

- Recon
  - High energy :

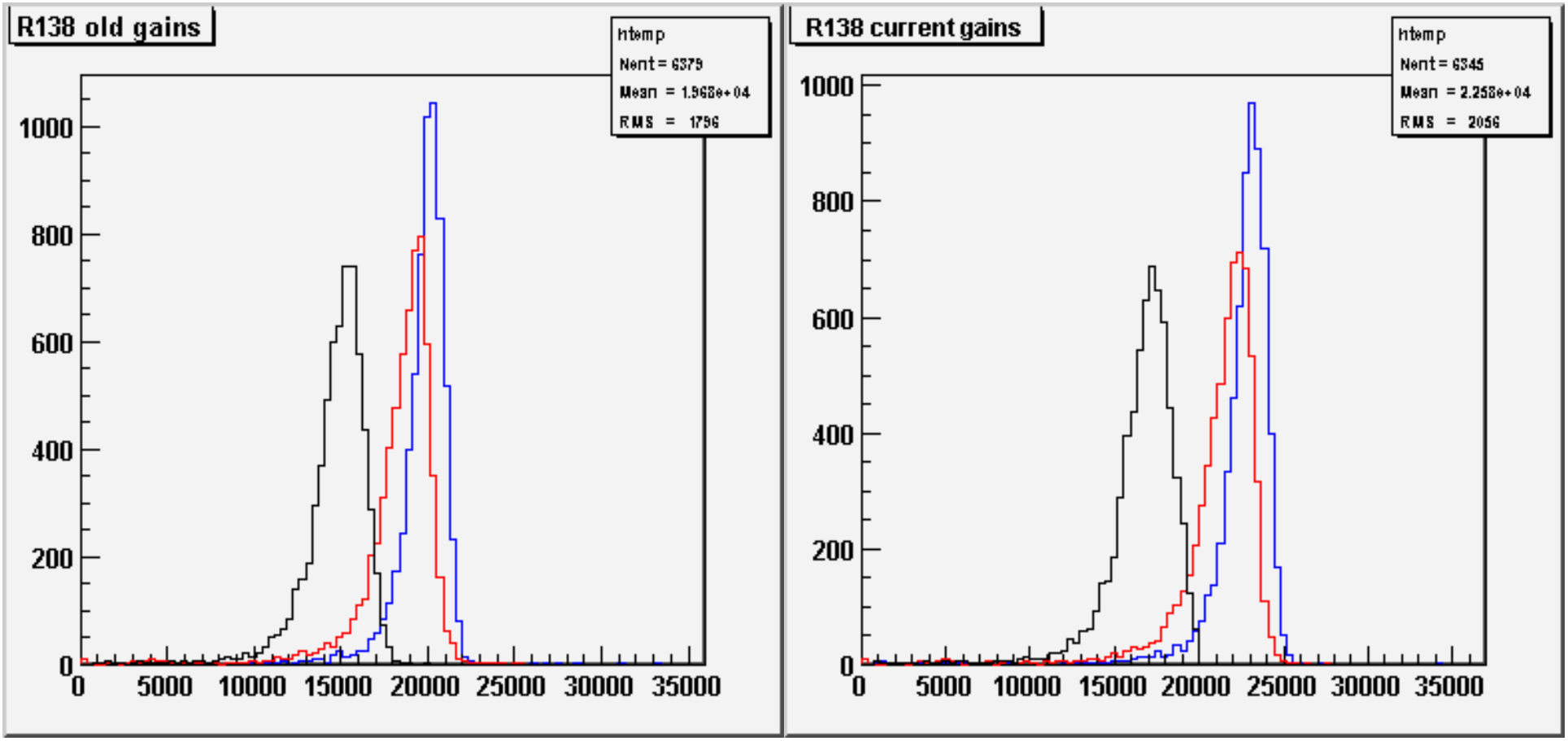
    2 correction algorithms have been tested and Implemented :
    - Profile fitting
    - Last layercorrelations (Ce7);
  - Low energy :
    - Correction prototype exists (see CAL s/w review)
    - Need TBSim installation on Linux @ CCPN (Lyon) done
    - Need for an up to date version of instrument.xml + noisy strips
    - Next steps : Run Tbsim to extract correction coefficients
    - Readapt the prototype; test it on MC data
    - Commit and begin TB low energy runs data analysis

Test Beam Status : TBRecon

- What we see is :
  - The Energy sum distribution is slightly tighter with new gains as compared to the one derived with old gains
  - But it is biased towards high energies as compared to TBSim :
    - The mode of the distribution is ~18 GeV instead of ~15
- As a result :
  - The Recon Corrected Energy distribution either with profile fitting or last layer (e7) correlation methods is biased to ~22-23 GeV

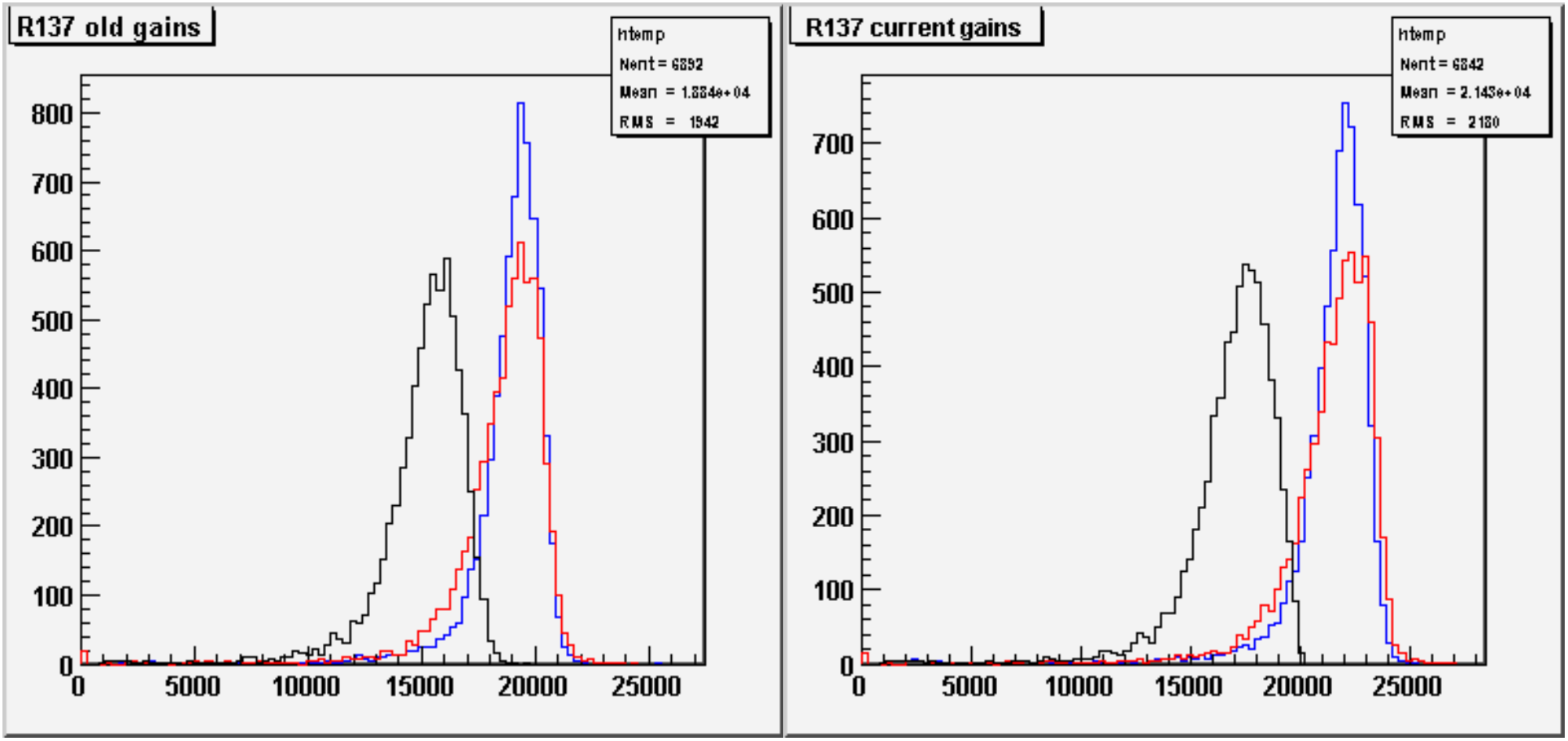
Test Beam Status : TBRecon

Run 138 : Black : Raw sum; Red : Profile ; Blue : Ce7



Test Beam Status : TBRecon

Run 137 : Black : Raw sum; Red : Profile ; Blue : Ce7



Test Beam Status : TBSim

- Calibration Files
  - Pedestal, Gains, Rails, Slopes, Int_lin files have been produced and committed ;
- Pedestals = 0 : the TBSim output is already pedestal subtracted
- Rails not relevant because Int_lin for sim = Identity;
- As Hits and Digis are still embedded in the CAL Sim branch :
  - the output of TBSim includes already the digitisation error
- As ROOTWriter "thinks" it is reading hits :
  - It digitizes once again => the digitization error is applied twice
    - Not a real issue, except maybe for low energy runs
  - It applies a factor 3/2 per log end (to correct for Light Atten)
- A special gain file has been committed to correct for the 3/2 factor.